UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE
OFFICE OF THE ADMINISTRATOR OF CIVIL AERONAUTICS
WASHINGTON 25, D. C.

TSO-C11 effective
August 1, 1948

TECHNICAL STANDARD ORDER

SUBJECT: FIRE DETECTORS

INTRODUCTION

Fire detectors are in the class of aircraft components which the Administrator of Civil Aeronautics is authorized to approve in accordance with Parts 04a and 04b of the Civil Air Regulations.

This Technical Standard Order is intended to serve as a criterion by which the product manufacturer can obtain Civil Aeronautics Administration approval of his fire detector.

In the establishment of this Technical Standard Order, consideration has been given to existing Government and industry standards for fire detectors for the purpose of adopting the performance requirements of one of the recognized aeronautical standards as the minimum safety requirements for fire detectors which are intended for use in civil aircraft. The specification of the Society of Automotive Engineers for fire detectors contains such requirements.

DIRECTIVE

Provision. Pursuant to Sections 04a.062, 04a.07, 04a.500, 04b.05 and 04b.38251 of the Civil Air Regulations, which authorize the Administrator to approve aircraft equipment, the performance requirements for fire detectors as set forth in SAE Specification AS-401, Fire and Heat Detectors, dated December 1, 1947,* with the exceptions hereinafter noted, are hereby established as minimum safety requirements for fire detectors which are intended for use in civil aircraft.

Exceptions. Item (b) of section 3.3 "Identification," need not be complied with for conformance with the terms of this Order.

Application. Fire detectors complying with the specifications appearing in this Technical Standard Order are hereby approved for all aircraft for protection of aircraft power plant installations, combustion heaters, or other installations where fuel, oil or similar fires may occur. Fire detectors already approved by the Administrator may continue to be installed in aircraft

(1) for which an application for original type certificate is made prior to the effective date of this Order,

*Copies may be obtained from the Society of Automotive Engineers, 29 W. 39th St., New York, N. Y.

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(2) the prototype of which is flown within one year after the effective date of this Order, and

(3) the prototype of which is not flown within one year after the effective date of this Order if due to causes beyond the applicant's control provided application for a type certificate is made prior to the effective date of this Order.

If a major change is made in the installation within nine months after the effective date of this Order involving a change in type or model of fire detector, previously approved types of fire detectors may be installed. However, in any such change made after the nine month period, new types of fire detectors installed in aircraft shall meet the specifications contained herein.

SPECIFIC INSTRUCTIONS

Marking. In addition to the identification information required in the referenced specification (see "Exceptions" above), each fire detector shall be permanently marked with the Technical Standard Order designation, CAA-TSO-C11, to identify the fire detector as meeting the requirements of this Order in accordance with the manufacturers' statement of conformance outlined below. This identification will be accepted by the Civil Aeronautics Administration as evidence that the established minimum safety requirements for fire detectors have been met.

Data Requirements. Ten copies of the following technical information shall be submitted by the manufacturer of the fire detector with his statement of conformance to the Civil Aeronautics Administration, Aircraft Service, Attn: A-298, Washington 25, D. C. These data shall consist of all information such as descriptive data, drawings, diagrams, etc., which are necessary to define the limitations of use for which the fire detectors are satisfactory, and which are essential to outline the conditions for their proper installation and operation. They shall include at least the following, wherever applicable, in addition to other limitations which may apply:

(1) maximum allowable normal ambient temperature at the point of detector location.

(2) maximum allowable rate of temperature rise at point of detector location as a result of normal operation.

(3) electrical circuit arrangement

(4) operating voltage

(5) mounting or support method

(6) maximum or minimum number of units or detector length which can be used in one circuit or one fire zone without adversely affecting sensitivity or causing false indications due to temperature variations associated with normal operation.

Effective Date. After August 1, 1948, specifications contained in this Technical Standard Order will constitute the basis for Civil Aeronautics Administration approval of fire detectors for use in certificated aircraft.

Deviations. Requests for deviation from, or waiver of, the requirements of this Order, which affect the basic airworthiness of the component, should be submitted for approval by the Director, Aircraft Service, Office of Aviation Safety, Civil Aeronautics Administration. These requests should be addressed to the nearest Regional Office of the Civil Aeronautics Administration, Attn: Superintendent, Aircraft Branch.

Conformance. The manufacturer shall furnish to the CAA (address as noted under "Data Requirements" above), a written statement of conformance signed by a responsible official of his company, setting forth that the fire detector to be produced by him meets the minimum safety requirements established in this Order. Immediately thereafter distribution of the fire detector conforming with the terms of this Order may be started and continued.

The prescribed identification on the fire detector does not relieve the aircraft manufacturer or owner of responsibility for the proper application of the fire detector in his aircraft, nor waive any of the requirements concerning type certification of the aircraft in accordance with existing Civil Air Regulations.

If complaints of nonconformance with the requirements of this Order are brought to the attention of the Civil Aeronautics Administration, and investigation indicates that such complaints are justified, the Administrator will take appropriate action to restrict the use of the product involved.

Copies of this Technical Standard Order and other Technical Standard Orders may be obtained from the Civil Aeronautics Administration, Aviation Information Staff, Washington 25, D. C.

F. B. Lee

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Acting Administrator of Civil Aeronautics

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AERONAUTICAL STANDARD AS 401

FIRE AND HEAT DETECTORS

Issued 12-1-47
Revised

1. PURPOSE: To specify minimum requirements for fire and heat detection instruments for use in aircraft, the operation of which may subject the instrument to environmental conditions specified in Section 3.4.

2. SCOPE: This specification covers the following basic types of instruments, or combinations thereof, intended for use in protecting aircraft power plant installations, auxiliary power plants, combustion heaters and other installation where fuel, oil or similar fires may occur.

Type I Rate of temperature rise
Type II Flame
Type III Fixed temperature

3. GENERAL REQUIREMENTS:

3.1 Materials and Workmanship:

3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 Radio Interference: The instrument shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft, either by radiation of feed-back, in radio sets installed in the same aircraft as the instrument.

3.3 Identification: The following information shall be legibly and permanently marked on the instrument or attached thereto:

(a) Name of Instrument
(b) SAE Spec. AS-401
(c) Rating (Electrical, Vacuum, etc.)
(d) Alarm Temperature (Sensing element, where applicable)
(e) Manufacturer's Part Number
(f) Manufacturer's Serial Number or Date of Manufacture
(g) Manufacturer's Name and/or Trademark

3.4 Environmental Conditions: The following conditions have been established as design criteria only. Tests shall be conducted as specified in Sections 5, 6 and 7.

3.4.1 Temperature: When mounted in accordance with the manufacturer's recommendations, the unit shall function over the range of ambient temperatures shown in Column A below and shall not be adversely affected by exposure to the temperatures shown in Column B below:

Instrument Location	A	B
Power Plant Compartments	-20 to 130C	-65 to 130C
Other Areas	-20 to 70C	-65 to 70C

3.4.2 Humidity: The instrument shall function and not be adversely affected by exposure to a relative humidity of up to and including 95% at a temperature of approximately 32 C.

3.4.3 Altitude: The instrument shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 feet to +40,000 feet standard altitude.

3.4.4 Vibration: When mounted in accordance with the instrument manufacturer's instructions, the units shall function and shall not be adversely affected when subjected to the following vibrations at a frequency of 500 to 3000 cycles per minute. When specified by the purchaser for use in rotary wing aircraft, the frequency range shall be 150 to 3000 cycles per minute.

Type of Instrument Mounting	Amplitude	Acceleration
Structurally Mounted Instruments	0.030 inch	3.8 g
Engine Compartment Mounted Instruments	0.20 inch	25 g

It is understood that the instrument shall withstand vibration at higher frequencies, but the acceleration values need not exceed those shown above.

4. DETAIL REQUIREMENTS:

4.1 Indicating Method: The instrument shall be capable of actuating both visual and aural alarm indicators.

4.2 Reliability: False signals in the instrument shall not result from variations in voltage between 0 and 125% of the rated. flight attitude, dust and accelerations encountered in flight or landing.

4.3 Integrity Test Provisions: The instrument shall permit testing of the continuity of the associated electrical circuit in flight.

4.4 Calibration Adjustment: All calibration adjustments in the instrument shall be provided with tamper-proof seals.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this specification shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 22 C. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowance shall be made for the variations from the specified conditions.

5.2 Vibration (To minimize friction): Unless otherwise specified, all tests for performance may be made with the instrument subjected to a vibration of .002 to .005 inches amplitude at a frequency of 1500 to 2000 cycles per minute. The term amplitude as used herein indicates the total displacement from positive maximum to negative maximum.

5.3 Vibration Stand: A vibration stand shall be used which will vibrate at any desired frequency between 500 and 3000 cycles per minute and shall subject the instrument to vibration such that a point on the instrument will describe, in a plane inclined 45 degrees to the horizontal plane, a circle, the diameter of which is equal to the amplitude specified herein.

5.4 Test Position: Unless otherwise specified, the instrument shall be mounted and tested in its normal operation position.

5.5 Power Conditions: Unless otherwise specified, all tests shall be conducted at the power rating recommended by the manufacturer and the instrument shall be in an operating condition.

5.6 Flame Temperature Measurement and Flame Size: All flame temperatures shall be measured by using an 18 gauge wire thermocouple and the two strands of wire shall be twisted together for a distance of ½ inch from the termocouple bead. The thermocouple bead shall be at the center of the flame and the two wires leading to the bead shall be parallel and extend radially into the flame. The nature and size of the flame and the method of test shall be specified in Figure 2.

5.7 Test Sample: Unless otherwise specified, when qualification tests are being conducted on continuous type detectors, at least eight inches of the continuous detecting element shall be subjected to the test conditions as well as at least two typical insulators, supports, or connectors of each basic type used.

6. INDIVIDUAL PERFORMANCE TESTS: All instruments or components of such shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this specification.

6.1 Response Time: The sensing element shall be tested as specified in Section 7.1, or in some equivalent manner which will adequatley check the sensitivity and calibration.

6.2 Dielectric: The instrument shall be subjected to whichever one of the following dielectric tests is most applicable:

6.2.1 Ungrounded instruments, or grounded instruments prior to connection of internal ground wire, shall be tested by either the method of Section 6.2.1.1 or 6.2.1.2.

6.2.1.1 Insulation Resistance: The insulation resistance measured at 500 volts d-c between all electrical circuits connected together and the metallic case shall not be less than 20 megohms.

6.2.1.2 Dielectric Strength: The insulation shall withstand without evidence of damage the application of a sinusoidal voltage at a commercial frequency between all electrical circuits connected together and the metallic case, for a period of 5 seconds. The RMS value of the sinusoidal voltage applied shall be either five (5) times the maximum instrument operating voltage, or 500 volts, whichever is the greater.

6.2.2 Instruments operated with a permanent internal ground connection shall be tested as follows:

The insulation shall withstand without evidence of damage the application of a sinusoidal voltage at a commercial frequency between each electric circuit and the metallic case, for a period of 5 seconds. The RMS value of the sinusoidal voltage applied shall be 1.25 times the maximum circuit operating voltage obtainable between two test points.

7. QUALIFICATION TESTS: As many instruments as appear necessary to demonstrate that all instruments will comply with the requirements of this section shall be subjected to the following tests where applicable. The tests on each instrument shall be conducted consecutively and after the tests have been initiated, no further adjustments of the instrument shall be permitted. There shall be no false alarms signalled during any of the tests. A response time test per Section 7.1 shall be conducted after each qualification test, except Sections 7.1.1, 7.2, 7.3, 7.3.1, 7.3.2, 7.3.3 and 7.14. However, except in the case of the response time test following the qualification test of Section 7.14, the instrument subjected to the response time test need not be the same instrument or instruments being subjected to the entire series of qualification tests.

7.1 Response Time: The sensing element shall be tested in an 815 C maximum temperature flame as specified in Figure 2. The ambient temperature from which the test is started shall be normal room temperature. However, a higher starting ambient temperature may be used if the sensing element is specified for use only in locations where the ambient temperature will not, under any normal continuous operating conditions, fall below this value. For types of detectors and detector systems whose sensitivity is affected by the number of sensing elements, by the length of the sensing element exposed to flame (for continuous types), or by other factors which may be varied from one system design to another, all response time tests shall be conducted with the least sensitive system configuration to be used. The time of response shall not exceed 5 seconds when the instrument is tested in accordance with this section.

7.1.1 Repeat Response Time: The sensing element(s) of the fire detector system shall be subjected to an 815 C flame for a period of one minute. It shall then be removed from the flame. Within 5 seconds after the alarm has cleared the sensing element shall again be subjected to the flame. An alarm shall be signalled in five seconds. The units subjected to this test need not be subjected to any other tests.

7.2 Fixed Temperature Operation: (For Type III instruments only). The detecting element shall be placed in a suitable heating chamber and the temperature shall be raised at the rate of not less than 7 C per minute, to not less than 80% of the rated temperature setting. The temperature shall be maintained at this value for not less than one hour. The temperature shall then be raised, at a rate of not more than 7 C per minute, to 10% above the rated temperature setting. An alarm shall be signalled within a tolerance of 10% of the rated temperature setting. The temperature shall then be lowered, at a rate of not more than 7 C per minute. The alarm indication shall cease before the temperature falls below 90% of the rated setting.

7.3 False Alarm Due to Rate of Temperature Rise: No alarm shall be signalled during these tests except in the case of Type III instruments which may signal an alarm when the temperature reaches a value not less than 90% of the rated setting. For types of detectors and detector systems whose sensitivity is affected by the number of sensing elements, the length of the sensing element exposed to the test temperature (for continuous types), or by other factors which may be varied from one system design to another, the tests of 7.3.1 and 7.3.2 shall be conducted with the most sensitive system configuration to be used.

7.3.1 False Alarm Due to Local Temperature Rise: The sensing element shall be subjected to various combinations of rates of temperature rise and durations of these rates of rise. Except as indicated in Section 7.3, no alarm shall be signalled when the element is exposed to any combination of the rates of rise and durations within the shaded area in Figure 3(a). This test shall be conducted in a manner simulating conditions due to local overheating.

7.3.2 False Alarm Due to General Temperature Rise: The test of 7.3.1 shall be repeated except that Figure 3(b) shall be employed and the test shall be conducted in a manner simulating conditions existing due to a general temperature rise throughout an engine compartment where the sensing element(s) may be located.

7.3.3 False Clearing of Alarm Due to Partial Extinguishing of Fire: The system configuration specified in 7.3 shall be subjected to an 815 C flame for 30 seconds. The flame shall then be removed from all except the portion of the system as specified in 7.1. The alarm shall not clear. After an additional 30 seconds the flame shall be removed entirely and the alarm shall then clear. The units subjected to this test need not be subjected to any other test.

7.4 Vibration: The instrument shall be mounted on a vibration stand, in its own shock mounted base, if provided with one, in its normal operating plane. The instrument shall be subjected to vibration with an amplitude between .003 and .005 inch at frequencies for 500 to 3000 cycles per minute, in order to determine whether the natural frequency of the instrument occurs in this frequency range.

7.5 Vibration Endurance: With the instrument mounted on a vibration stand, per Section 7.4, it shall be vibrated continuously at a total amplitude as specified in Section 3.4.4 for a period of 24 hours at the natural frequency, if applicable, as determined in Section 7.4, or if not applicable, at a frequency of 2000 cycles per minute. No damage shall be evident after this test. In the case of this test, the response time test of 7.1.1 shall be conducted while the instrument is being vibrated. However, the sensing and indicating elements need not be vibrated simultaneously unless it is apparent that simultaneous vibration will be critical.

7.6 Water Spray: All parts of the instrument which may be installed in exposed portions of the airplane shall be subjected to the following tests:

7.6.1 Simulated Rain: The components being tested shall be subjected to a spray of water, to simulate rain, for a period of three hours. The detector shall not be dried prior to testing per Section 7.1.

7.6.2 Salt Spray: The components being tested shall be subjected to spray with a 20% sodium chloride solution for a period of fifteen minutes. The components shall then be dried in air at room temperature before they are tested per Section 7.1. The components shall not be cleaned before the test of Section 7.1 is conducted.

7.7 Corrosion: All parts of the instrument which may be installed in exposed portions of the airplane shall be subjected to a finely atomized spray of 20% sodium chloride solution for 200 hours. At the end of this period the parts shall be allowed to dry and may then be cleaned prior to conducting the test per Section 7.1.

7.8 Fuel and Oil Immersion: All parts of the instrument which may be located in engine compartments, or other locations where they may be contaminated by fuel or oil, shall be subjected to the following tests:

7.8.1 Fuel Immersion: The components being tested shall be thoroughly immersed in normally leaded 100 octane fuel at approximately room temperature and then allowed to drain for one minute before being tested per Section 7.1. No cleaning other than the drainage specified above shall be accomplished prior to conducting subsequent tests.

7.8.2 Oil Immersion: The same test shall be conducted with used SAE #60 oil.

7.9 Sand: All parts of the instrument which may be installed in exposed portions of the airplane (such as in nacelles, wheel wells, etc.) shall be subjected to a sand or dust laden air stream, flowing at a constant rate of 2½ pounds per hour, for four hours. The stream shall be formed of sand or dust that has been sifted through a 150 mesh screen and shall pass over all parts of the units under test. The test chamber shall be equivelant to that shown in Figure 1.

7.10 High Temperature: All components of the instrument which may be located in engine compartments shall be exposed to a temperature of 130 C for 48 hours prior to being tested per Section 7.1 except a 130 C. All other components shall be subjected to a similar test at 70 C.

7.11 Low Temperature: The instrument shall be exposed to a temperature of -65 C for a period of 24 hours, after which it shall be raised to a temperature of -55 C for a period of six hours prior to being tested per Section 6.1 except at -55 C. However, compliance with Section 7.1 shall be considered to have been accomplished in this case if the time of response does not exceed 10 seconds.

7.12 Altitude Effects:

7.12.1 High Altitude and Rate of Climb: The instrument shall be subjected to a pressure that is varied from normal atmospheric pressure to an altitude pressure equivalent to 40,000 feet at a rate of not less than 3000 feet per minute. The instrument shall be maintained at the altitude pressure equivalent to 40,000 feet for a period of 48 hours. The instrument shall then be returned to sea level conditions and then tested per Section 7.1. Sealed units shall not leak as a result of exposure to this pressure. Where applicable, this shall be demonstrated by immersion in water after the test.

7.12.2 Low Altitude: The instrument shall be subjected to the same test as outlined in Section 7.12.1, except that the rate of pressure variation need not be as specified therein and the pressure shall be maintained at an altitude pressure equivalent to -1000 feet.

7.12.3 Pressurization Test: All components of the instrument which may be located in pressurized area shall be subjected to an external pressure of 8 p.s.i. for a period of fifteen minutes. The response time test of 7.1.1 shall be conducted while the components involved are under the 8 p.s.i. pressure.

7.13 Voltage Variation: The instrument shall be operated with the voltage varying from 110% to 75% of the rated. The instrument shall then be tested per Section 6.1 under these conditions. Compliance with the provisions of Section 4.2 shall also be demonstrated.

7.14 Flame: The detecting element of the instrument shall be subjected to a completely enveloping flame at a temperature of 1100 C minimum for two periods of one minute each. The flame shall be as specified in Figure 2. The instrument shall be cooled to approximately room temperature or to the ambient temperature permitted in Section 7.2 after each exposure to flame. The instrument shall then be exposed to the same flame a third time. An alarm shall be signalled in not more than five seconds after each exposure to flame. During cooling of the instrument after the first two exposures to flame the alarm shall clear in not more than 45 seconds after the flame has been removed in the first two cases. Artificial means of cooling the instrument shall not be used until after the alarm has cleared. A manual resetting device may be used to clear the alarm provided it is demonstrated that the resetting device will clear the alarm only if the flame has been removed; i.e., if flame is still present and the manual resetting device is operated, the instrument must continue to indicate the presence of a fire. The instrument need not clear the alarm and need not be capable of further operation after the third exposure to flame. During this test the sensing element shall be subjected to vibration as specified in Section 7.5.

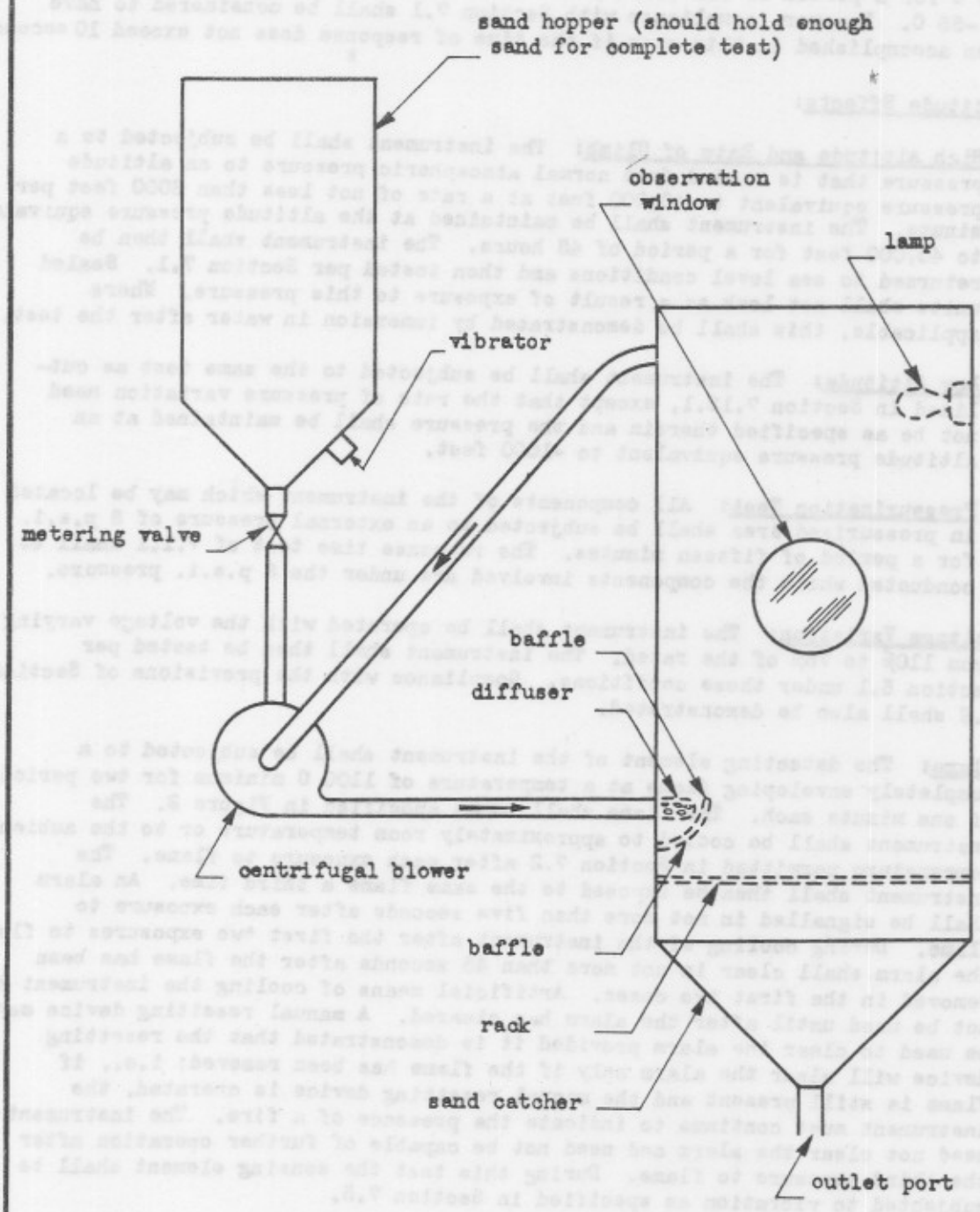

FIGURE 1
Schematic Sand Test Arrangement (Ref. Section 7.9)

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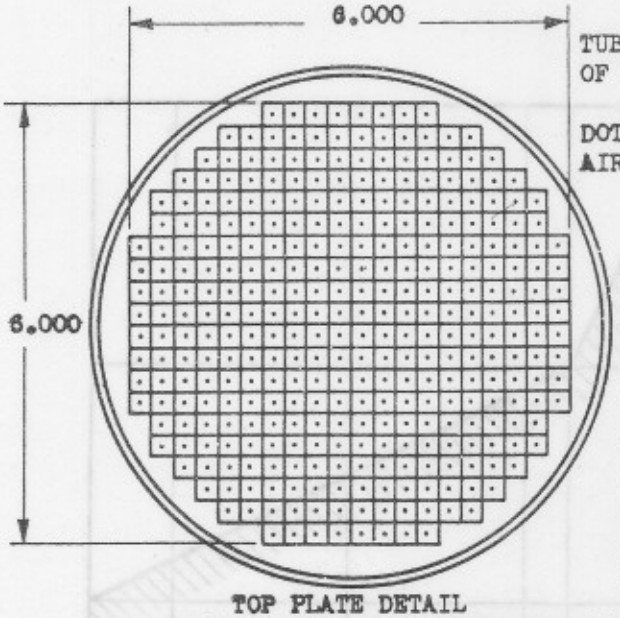


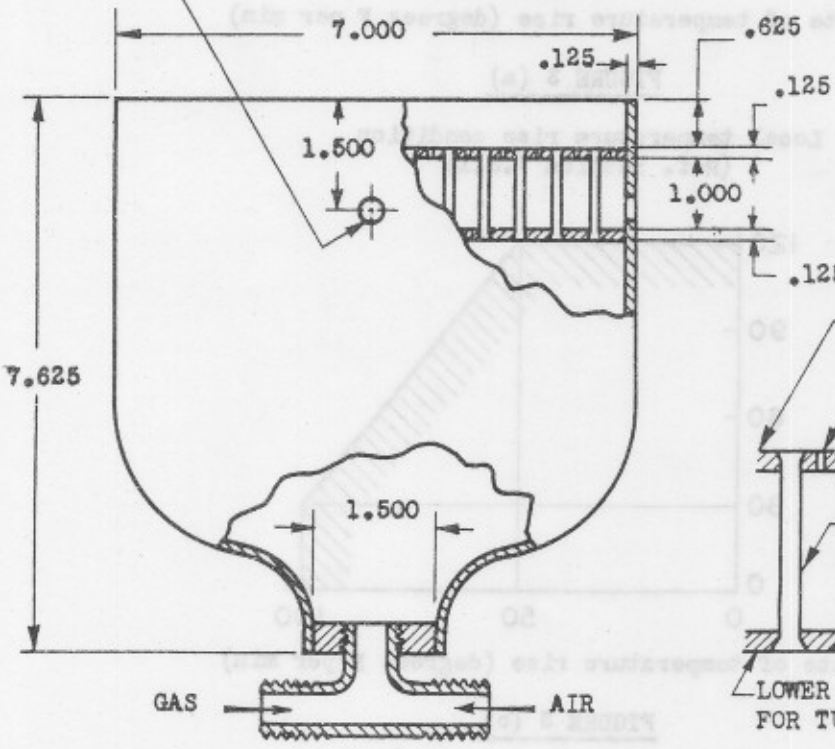
TUBES LOCATED AT INTERSECTION OF SOLID LINES

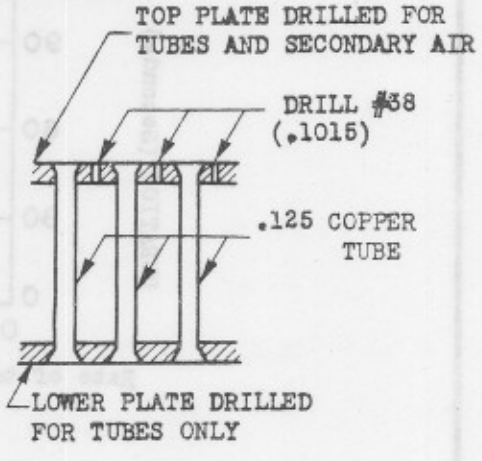
DOTS LOCATE SECONDARY AIR HOLES

NOTE

The burner should consume 65,000 Btu per hour in producing the 2000-degree flame, and 30,000 Btu per hour in producing the 1500-degree flame. With these quantities of gas (bottled, 2500 Btu per cubic foot), the air should be adjusted so as to give a uniform steady flame of the desired temperature, with no yellow tips appearing above the blue flames.

TOP PLATE DETAIL
4.125 PIPE TAPS, SPACED EQUALLY FOR SECONDARY AIR





TUBING DETAIL

FIGURE 2

Flame Tewt Burner (Ref. Sections 5.6, 7.1 and 7.14)

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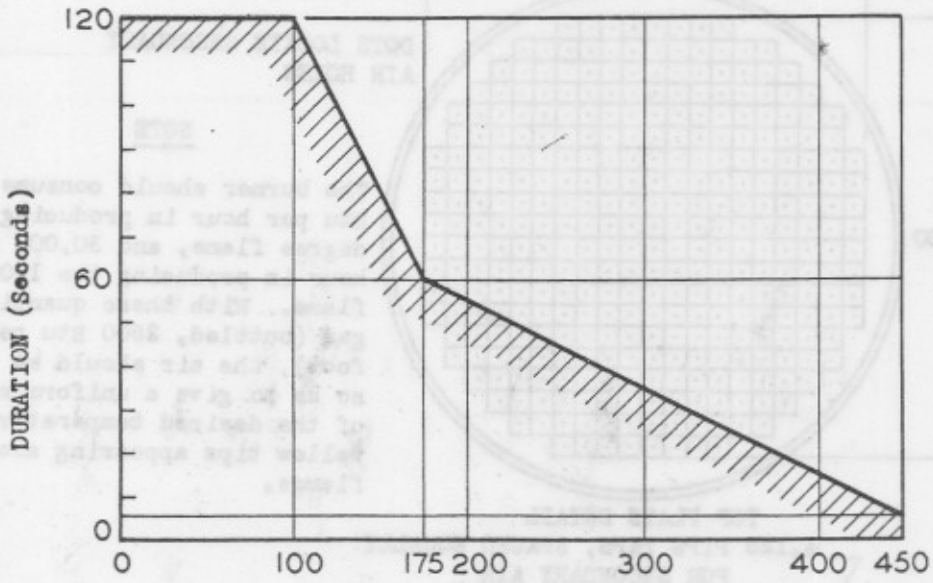

FIGURE 3 (a)

Local temperature rise condition
(Ref. Section 7.3.1)

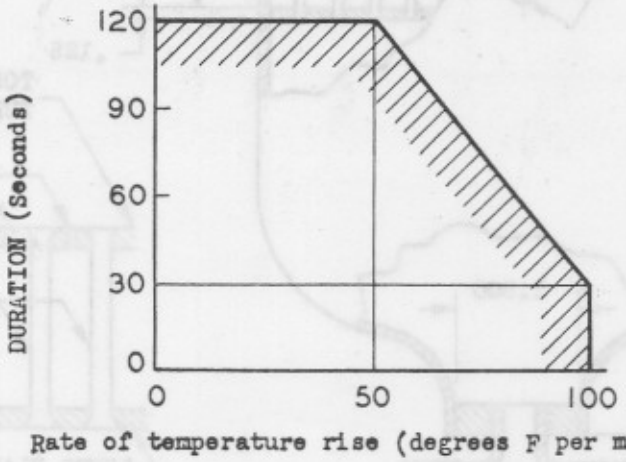

FIGURE 3 (b)

General temperature rise condition
Ref. Section 7.3.2)

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